Landslides

A **landslide** or **landslip** is a geological phenomenon which includes a wide range of ground movement, such as rockfalls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Geologists often refer to these as **mass movement.**

Although the action of gravity is the main driving force for a landslide to occur, there are other contributing factors affecting the original *slope stability*. Usually there are certain factors that build up specific sub-surface conditions that make the area/slope prone to failure. Then the actual landslide often requires a trigger before being released, such as a rain downpour or an earthquake.

What causes landslides

Landslides occur when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone. Natural causes of landslides include:

- groundwater (porewater) pressure acting to destabilize the slope
- Loss or absence of vegetation cover, soil nutrients, and soil structure (e.g. after a wildfire)
- erosion of the toe of a slope by rivers or ocean waves
- weakening of a slope through saturation by snowmelt, glaciers melting, or heavy rains
- earthquakes adding loads to barely stable slope
- earthquake-caused liquefaction destabilizing slopes
- volcanic eruptions

Landslides are aggravated by human activities, Human causes include:

- deforestation, cultivation and construction, which destabilize the already fragile slopes
- vibrations from machinery or traffic
- blasting
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock
- Construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

The landslide at Surte in Sweden, 1950. It was a quick clay slide killing one person.

Landslide types

Debris flow

Amboori debris flow, occurred on 9 November 2001 in Kerala, India. The event killed 39 people.

Slope material that becomes saturated with water may develop into a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses and cars, thus blocking bridges and tributaries causing flooding along its path.

Debris flow is often mistaken for flash flood, but they are entirely different processes. Muddy-debris flows in alpine areas cause severe damage to structures and infrastructure and often claim human lives. Muddy-debris flows can start as a result of slope-related factors and shallow landslides can dam stream beds, resulting in temporary water blockage. As the impoundments fail, a "domino effect" may be created, with a remarkable growth in the volume of the flowing mass, which takes up the debris in the stream channel. The solid-liquid mixture can reach densities of up to 2 tons/m³ and velocities of up to 14 m/s). These processes normally cause the first severe road interruptions, due not only to deposits accumulated on the road (from several cubic metres to hundreds of cubic metres), but in some cases to the complete removal of bridges or roadways or railways crossing the stream channel. A New Zealand example is the **Tangiwai disaster,** a volcanic debris flow (lahar).

Earth flow

Earthflows are downslope, viscous flows of saturated, fine-grained materials, which move at any speed from slow to fast. Typically, they can move at speeds from 0.17 to 20 km/h. Though these are a lot like mudflows, overall they are slower moving and are covered with solid material carried along by flow from within. They are different from fluid

flows in that they are more rapid. Clay, fine sand and silt, and fine-grained, pyroclastic material are all susceptible to earthflows. The velocity of the earthflow is all dependent on how much water content is in the flow itself: if there is more water content in the flow, the higher the velocity will be.

These flows usually begin when the pore pressures in a fine-grained mass increase until enough of the weight of the material is supported by pore water to significantly decrease the internal shearing strength of the material. This thereby creates a bulging lobe which advances with a slow, rolling motion. As these lobes spread out, drainage of the mass increases and the margins dry out, thereby lowering the overall velocity of the flow. This process causes the flow to thicken. The bulbous variety of earthflows are not that spectacular, but they are much more common than their rapid counterparts. They develop a sag at their heads and are usually derived from the slumping at the source. *A rock slide in Guerrero, Mexico*
Earthflows occur much more during periods of high precipitation, which saturates the ground and adds water to the slope content. Fissures develop during the movement of clay-like material creates the intrusion of water into the earthflows. Water then increases the pore-water pressure and reduces the shearing strength of the material.

Debris avalanche
Goodell Creek Debris Avalanche, Washington
A debris avalanche is a type of slide characterized by the chaotic movement of rocks soil and debris mixed with water or ice (or both). They are usually triggered by the saturation of thickly vegetated slopes which results in an incoherent mixture of broken timber, smaller vegetation and other debris. Debris avalanches differ from debris slides because their movement is much more rapid. This is usually a result of lower cohesion or higher water content and commonly steeper slopes.

Shallow landslide
Hotel Limone at the Lake Garda. Part of a hill of Devonian shale was removed to make the road, forming a dip-slope. The upper block detached along a bedding plane and is sliding down the hill, forming a jumbled pile of rock at the toe of the slide.

This is a landslide in which the sliding surface is located within the soil mantle or weathered bedrock (typically to a depth from few decimetres to some metres). They usually include debris slides, debris flow, and failures of road cut-slopes. Landslides occurring as single large blocks of rock moving slowly down slope are sometimes called block glides.
Shallow landslides can often happen in areas that have slopes with high permeable soils on top of low permeable bottom soils. The low permeable, bottom soils trap the water in the shallower, high permeable soils creating high water pressure in the top soils. As the top soils are filled with water and become heavy, slopes can become very unstable and slide over the low permeable bottom soils. Say there is a slope with silt and sand as its top soil and bedrock as its bottom soil. During an intense rainstorm, the bedrock will keep the rain trapped in the top soils of silt and sand. As the topsoil becomes saturated and heavy, it can start to slide over the bedrock and become a shallow landslide. R. H. Campbell did a study on shallow landslides on Santa Cruz Island California. He notes that if permeability decreases with depth, a perched water table may develop in soils at intense precipitation. When pore water pressures are sufficient to reduce effective normal stress to a critical level, failure occurs.

Causing tsunamis
Landslides that occur undersea, or have impact into water, can generate tsunamis. Massive landslides can also generate megatsunamis, which are usually hundreds of meters high. In 1958, one such tsunami occurred in Lituya Bay in Alaska.One of the larger underwater landslides that has done this is the Ruatoria debris avalanche, on the slopes of the Hikurangi Trench off the East Coast of the North Island.

NZ Landslides: Look up:
Abbotsford Landslide disaster
Ruahihi Power Canal collapse
Tangiwai disaster
Otira viaduct